Getting Started in Digital Communications - Part 1 - Introduction

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Getting Started in Digital Communications

Part 1—There's been a tremendous surge of interest in digital communications. Find out what's going on—and how you can get involved!

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A modern, fully equipped station for digital communications.

I have a friend—whose name and call shall remain anonymous—who refuses to have anything to do with digital communications. I've tried to gently nudge him into packet, but he dismisses my efforts with a smile and says, "Nah. You know I don't like that digital stuff." He'll be an analog man to his dying day and that's fine. (The beauty of Amateur Radio is that it offers something for everyone.) I still can't help but pity him, though. He'll never have the chance to experience the magic of the digital modes!

What are the Digital Modes?

Put this question to most hams and the first word to cross their lips will probably be *packet*. After some further thought they may add AMTOR and RTTY, but how many will remember to include CW?

Yes, you read that last sentence correctly. CW is the granddaddy of digital communications! If you're skeptical, consider the fact that CW meets all the criteria for being classified as a digital mode. The original information is converted to a standardized code (International Morse) for transmission. The CW signal is then decoded at the receiving end and the information is recovered. Like many other digital modes, CW is capable of high-speed communications and makes efficient use of the available spectrum.

Enter the Computer

With the advent of cheap personal computers in the '80s, hams suddenly discovered new ways to manipulate digital information faster and more efficiently than ever before. Old RTTY teleprinters were gradually replaced with monitor screens. Some hams abandoned their straight keys, bugs and paddles in favor of sending consistently perfect CW from their computer keyboards. The flexible processing capability of the personal computer also opened the door to AMTOR (an error-correcting form of RTTY) and packet. We'll discuss packet, RTTY and AMTOR individually in future installments of this series.

The Future Beckons

Even as you read this sentence, new digital modes are on the horizon. Someday the transmission of speech itself will become digitized, virtually eliminating interference and producing clear, high-fidelity audio. You don't believe it? Well, keep your eyes on digital audio broadcasting (DAB). The technology is available *now* and broadcasters are already talking to the FCC about DAB frequency allocations. With the trickle-down nature of technology, it's only a matter of time before digital speech transmissions become an Amateur Radio reality.

Future hams will probably look back on the last two decades of this century as the beginning of the Digital Era. The technological advancements in our time may seem as monumental as the transition from the spark gap to the vacuum tube. Like my dyed-in-the-wool analog friend, not everyone welcomes such radical changes. If you've read this far, however, you're obviously not afraid to try something new. Let's take a look at the components you'll need to get started in digital communications!

HF Gear

If you favor the HF bands, you'll find that most modern transceivers are very accommodating to digital modes. If you're considering Mode-A ARQ AMTOR (that *chirp-chirp-chirp* sound you hear below the SSB subbands), check the specifications to determine if your rig can switch from transmit to receive very rapidly. (The same is true for amplifiers.) Mode-A AMTOR requires a transmit/receive turnaround time of 20 milliseconds or less. *QST* Product Reviews list these measurements.

If your interest lies in RTTY, you'll need a rig that can tolerate *high-duty-cycle* transmissions for extended periods of time. High duty cycle means that the transmitter is driven to its maximum rated output during the entire transmission. (CW and SSB are

low-duty-cycle modes since they cause the transmitter to produce full output for only brief intervals.) Many modern rigs are rated for high-duty-cycle use, but some must be operated at reduced output. Check the specifications *first* and abide by them.

Older rigs are often less tolerant of high-speed switching and high-duty-cycle transmissions. You may find, for example, that Mode-A AMTOR is impossible on many vintage radios. Most older SSB transmitters and transceivers should be RTTY compatible—although you'll have to be careful not to exceed their specifications for continuous output power! When in doubt, watch your output meter and reduce the maximum reading by 50% or more. If your rig still overheats, consider running less power and/or installing a fan to cool the final amplifier stage.

Received-signal filtering is another item to consider. Once again, most modern transceivers provide adequate filters for digital operation. Even older radios usually include fixed or variable audio filters. It isn't an absolute requirement, but if you're going to be operating in heavy QRM conditions (such as contests), or if you're chasing weak signals, audio filtering is a definite asset!

Finally, there is the issue of frequency stability. For HF digital communications you need a rig that is as stable as possible. This is particularly important for HF packet since most digital interfaces tolerate only a small amount of frequency drift. I've successfully operated HF packet with my 25-year-old Drake tube transceiver, but I have to let it "cook" for about 30 minutes before I begin. Even with a decent warm-up, it still drifts slightly. I have to watch my tuning indicator and make *very* careful VFO adjustments to stay on the correct frequency. RTTY is more forgiving, but a warm-up period is still a good idea.

Here's an easy rule of thumb for selecting an HF transceiver for digital applications: If you intend to operate packet or Mode-A AMTOR, buy a rig that was manufactured within the last five to ten years. If your only interest is RTTY, almost any good-quality radio made within the last 30 years will do the job.

VHF/UHF Radios

On VHF and UHF, packet is the king of digital communications. Since packet transmissions are relatively brief bursts, you generally don't have to be concerned about duty cycles and output-power ratings.

Although FM transceivers are designed to transmit and receive human speech, most models also function as packet radios without complaint. Among those transceivers that balk at the task of transmitting or receiving packet, the main problem involves audio frequency response. They're either incapable of transmitting the full range of audio frequencies that comprise a packet burst, or they have a limited frequency response for received signals. If you're unfortunate enough to own one of these rigs, the best approach is to consult the manufacturer for possible modifications to correct the condition.

Providing the proper audio level to the transceiver is also important for packet communications. FM transmitters modulate their signals by shifting, or *deviating*, their output frequency in response to changes in audio amplitude at the input. Perhaps you've heard someone on your local repeater complain that a transmitter is "over-deviating." This is another way of saying that the rig is being overmodulated, causing its frequency to shift beyond the passband of the repeater's receiver. For the sake of clarity, it's easiest to think of deviation in the same terms as audio level or loudness.

For packet communications, you'll want to find a happy medium between having a signal that's too loud or too weak. Over-deviation distorts your signal and causes data loss. Under-deviation is just as bad because the receiving stations won't be able to hear your packets well enough to decode them. Most packet TNCs and multimode communications processors offer some form of audio-output adjustment. Borrow another receiver and compare the loudness of your packet bursts to others, or have other hams listen and offer their opinions. In most instances these simple tests will be sufficient. If you're concerned about having just the right deviation level, you'll have to find someone who has access to the proper test equipment to measure the exact deviation of your transmitter during packet operation.

The Computer

When the personal computer invasion began, a number of low-end models battled for market dominance. In the early '80s you could find amateur-oriented software and hardware for the Tandy Color Computer, the Atari, the Commodore 64 and several others. The Commodore 64s (and the 128s that followed) finally captured the

Get Keyed Up!

TNCs and MCPs use solid-state switching for transmitter control—particularly when operating RTTY, AMTOR, ASCII and packet. (Some MCPs employ an internal relay for CW keying.) Solid-state switching is fast and efficient. It's perfect for modern transceivers, but it can cause problems when applied to older rigs (particularly tube radios).

Marrying today's technology to yesterday's equipment can be a challenge, but it's not impossible. One easy solution is to buy a small 12-V relay and wire it to the TNC or MCP as shown in Fig 1. The relay acts as an isolator between the interface and the rig. The TNC or MCP keys the relay which, in turn, keys the radio. More elegant solutions are possible using solid-state devices. See "Cheap and Easy Control-Signal Level Converters" by James Galm, WB8WTS, in February 1990 *QST*, pages 24-27.

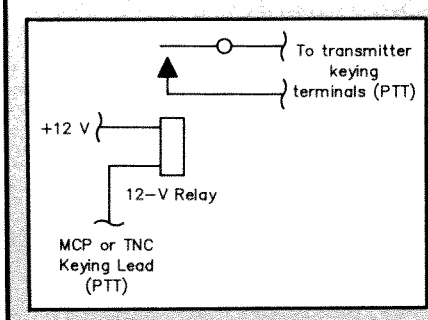


Fig 1—A small relay can be used to key older transceivers.

Another frequent problem involves the use of hand-held transceivers for packet. Here are a few suggestions for keying ICOM, Kenwood and Yaesu hand-helds:

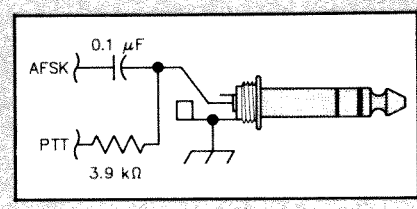


Fig 2—Keying schematic for ICOM hand-helds.

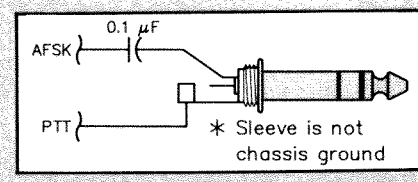


Fig 3—Keying schematic for Kenwood hand-helds. (Chassis ground is provided through the external-speaker jack.)

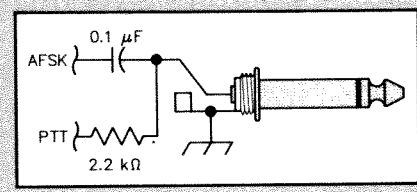
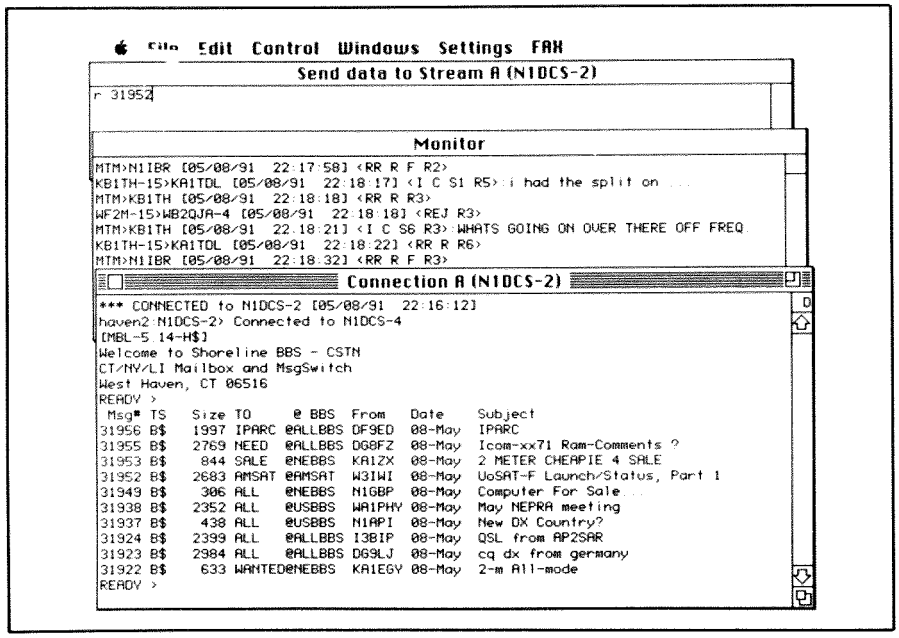


Fig 4—Keying schematic for Yaesu hand-helds



MacRATT is an example of an Amateur Radio digital communications software package written for the Apple Macintosh.

If you want several digital modes at your fingertips, multimode communications processors (MCPs) are ideal. Shown from top to bottom are the MFJ-1278, the AEA PK-232MBX and the Kantronics KAM.

amateur spotlight by the middle of the decade, but IBM PCs and compatibles were gaining ground. Plummeting prices made PCs increasingly attractive to hams who wanted the speed, power and other features they offered.

With all due respect to owners of Apples, Commodores and other computer brands, it's fair to say that PCs have become the de facto standard in Amateur Radio today. This doesn't mean that other models are unusable for digital communications, though. If you have (or can get) a terminal-emulation program for your computer, you're halfway there. The second hurdle involves getting your computer to talk to your TNC or MCP. Most manufacturers of interfaces and communications processors provide information to assist you in wiring your computer to their devices. Until just a few months ago, for example, I did all of my packet operating with a Tandy Color Computer 3. A cheap terminal program allowed me to communicate with my packet TNC through the Color Computer's serial port.

Virtually any personal computer is sufficient to get you off and running. There are a few factors to consider before making your choice, however:

• *I/O* (input/output): Does the computer have a port to allow it to easily communicate with the outside world? Most digital interfaces require a standard RS-232-C *serial* connection to the computer—although some also accept a *TTL* (transistor-transistor logic) connection.

• *Software*: Is there a terminal-emulation program available for the computer? Can the computer run other types of Amateur Radio software?

• *Memory*: How much random-access memory (RAM) is available? Even though you may have located a terminal program and other software, you may be disappointed to find that their performance is limited by a lack of on-board RAM. When it comes to memory, the more the better.

• *Data storage*: Does the computer offer some form of reliable data storage (preferably floppy disks or a hard disk)?

• *Interference*: Does the computer bombard your receiver with RF of its own making? How does it respond to *your* signals? Ask any ham who's active in digital communications and you'll discover that mutual interference can be a major headache! (One of the shortcomings of my Color Computer was its ability to generate annoying signals on just about any band!) Before you surrender your hard-earned cash, ask other hams about their experiences with the model you have in mind. If you've already bought the computer, you may have to acquaint yourself with RFI-suppression techniques![1]

[1]Notes appear on page 37.

• *Support*: If your computer suddenly becomes demented, is there anyone on the planet who remembers how to fix it? What about the availability of replacement parts and accessories?

The kind of computer that's best for you will ultimately depend on your budget and your goals. If you're a little unsure about digital communications, start small and work your way up. You can buy an older low-end computer and then upgrade to a modern model as you become more experienced. Commodores and Color Computers can be had for peanuts at hamfest flea markets. Even low-end IBM PC compatibles are selling for bargain prices.

If you want to jump in with both feet, consider stretching your funds to purchase the best computer you can afford. Your investment will pay off in convenience, speed and reliability. Chances are good that you'll be doing more than Amateur Radio work with your new machine, so choose a computer that's easy to upgrade as your needs change.

The Analog/Digital Interface

Having an affordable personal computer is one thing. Getting it to work with Amateur Radio equipment is another! Many modern transceivers provide the means for external computer *control* of their functions. This control capability is very convenient, but we need to use the computer to *communicate*!

It's important to remember that a computer is strictly a digital device. It can only understand the presence or absence of small voltage levels at precise moments in time (data). Strict rules govern its operation and it's very unforgiving when those rules are violated. A transceiver, on the other hand, is analog in nature. It receives and transmits signals of varying amplitudes and frequencies. Its rules are few and it usually forgives all but the most abusive operators. Despite its flexibility, however, you can't feed computer data directly into its microphone, RTTY or CW jacks and expect to transmit a usable signal. By the same token, its analog audio output is totally incomprehensible from a computer's point of view.

So how do we get these two incompatible devices to work together in harmony? We need something to serve as a bridge between the digital and analog worlds—in other words, an *interface*. The interface must accept digital data from the computer and translate it into audio signals (or on/off keying) for the transceiver. The interface must also accept audio from the transceiver and convert it into digital data for the computer. This two-way function is basically an act of *mo*dulating and *demo*dulating. Combine the italicized letters and what do you get? MODEM!

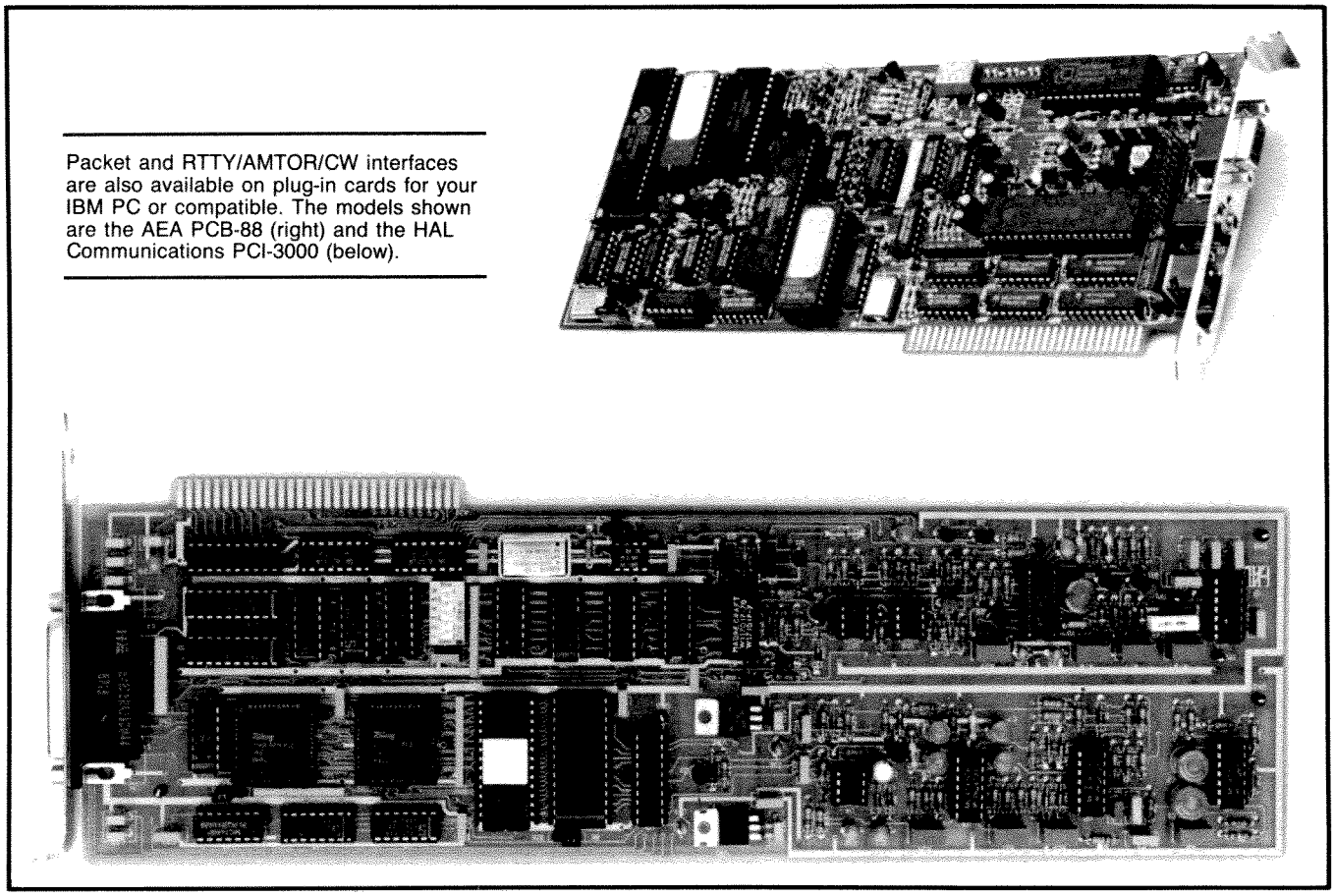
Just as we have modems to connect computers to telephone lines, we also have modems to connect computers to Amateur Radio equipment. The first Amateur Radio modems were fairly simple devices dedicated to one or two modes (such as RTTY and CW). Packet modems (called Terminal Node Controllers or TNCs) arrived later. They were far more sophisticated with built-in microprocessors, memories and software. Although TNCs functioned as interfaces, they were smart devices—essentially computers themselves.

Multimode Communications Processors

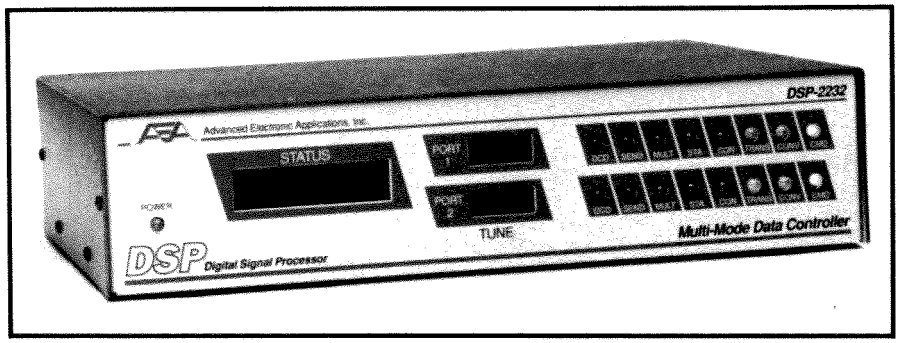
As digital technology evolved, it wasn't long before someone said, "Why should I have to use one interface for packet and another for RTTY? Why can't they all be together in one box?"

Why not, indeed? Not only did manufacturers place packet and RTTY together in the same box, they added several other modes for good measure. The result was the *multimode communications processor* (or MCP)—probably one of the most popular pieces of equipment for the digital ham today.[2]

Like packet TNCs, MCPs incorporate microprocessor design and internal memory. By issuing a single command from the computer keyboard, you can switch the MCP from packet (HF or VHF), to AMTOR, to RTTY or even CW. Some models also add fax, ASCII, NAVTEX and SSTV to their list of modes.



Packet and RTTY/AMTOR/CW interfaces are also available on plug-in cards for your IBM PC or compatible. The models shown are the AEA PCB-88 (right) and the HAL Communications PCI-3000 (below).



Multimode communications processors with DSP (digital signal processing) are already available. The AEA model DSP-2232 is shown above.

Just about any terminal program can be used to communicate with your MCP. Most standard terminal programs, however, are designed to communicate over telephone lines and may be a bit awkward when used for Amateur Radio applications. If you plan to buy an MCP, consider purchasing terminal software specifically designed with hams in mind. Most MCP manufacturers offer software packages for their own devices, or you can buy third party software. The fourth edition of the *ARRL Operating Manual* offers a list of popular programs for several computers.[3]

To Multi or Not to Multi?

Few would argue with the claim that MCPs are versatile devices for digital communications. They've brought a smorgasbord of operating modes within the reach of average hams. I've spent many evenings tuning through the bands, switching my MCP from one digital mode to another as the spirit moved me. The sheer convenience of an MCP is highly addictive!

Even with all of the MCPs' advantages, you still need to pause and ask yourself, "Do I really need a full-featured multimode processor?" If you want the freedom to easily explore a variety of digital modes, the answer may be yes. On the other hand, if your interests are more focused (RTTY or packet only), you may be better off with a basic packet TNC or specialized RTTY/AMTOR equipment. As I said before, it all depends on your desires and your budget.

Digital Signal Processing

Now that I've given you the basics on MCPs and other digital communications equipment, it's time to tell you about an exciting new technology that has just arrived. It's called *digital signal processing* or DSP.

Before you throw up your hands in despair and confusion, be assured that today's digital communications equipment is perfectly useful and will remain so for many years to come. You can still buy that new multimode communications processor and enjoy a long, happy relationship.

As the term implies, digital signal processing involves an entirely digital approach to decoding and encoding signals for various modes. The main advantage of DSP communications processors is their flexibility. Standard MCPs can also achieve a certain amount of flexibility, but they are ultimately limited by their internal hardware.

For example, you can add a new digital mode to a standard MCP by substituting an EPROM that has been programmed with new software. This approach works just fine as long as the hardware components (specialized ICs and other circuitry) can also support the new mode. But what if you want the processor to perform a task that's beyond the capability of its existing hardware?

Consider phase shift keying (PSK). It's the required mode for many packet satellites. None of the standard multimode communications processors on the market today contain the hardware necessary to generate a PSK signal. If you want to operate the Pacsats, you have to purchase a separate PSK modem to convert the output of your MCP to PSK format.

With a DSP processor, you can add virtually *any* mode to the unit by simply adding new software. Unlike standard communications processors, DSP units use their software to directly encode and decode desired signals without depending on specialized hardware. The finer details are well beyond the scope of this article, but you'll be hearing a lot more about DSP in the months and years to come.

A few DSP multimode communications processors are already available. Buying a DSP unit will require a substantial cash investment, but this is normal for emerging technology. If you were around when packet TNCs made their debut, you'll remember how expensive they were at the time! DSP is more than just another clever product feature; Digital signal processing has the potential to revolutionize Amateur Radio communications.[4]

Next Month

Next month, we'll start talking about specific digital communication modes. The best place to begin is with the mode that has captured the interest of more amateurs than any other: packet!

Notes

[1]*Radio Frequency Interference: How to Find It and Fix It*, is a valuable new reference available from the ARRL. See the ARRL Publications Catalog elsewhere in this issue for ordering information.
[2]Multimode communications processors are also commonly known as *multimode controllers*.
[3]The fourth edition of *The ARRL Operating Manual* provides a sampler of terminal-emulation software for a variety of computers. See page 10-2.
[4]B. Hale, "An Introduction to Digital Signal Processing," *QST*, Jul 1991, pp 35-37.